Surface Tension Measurements in Microgravity

I. Egry, B. Feuerbacher, G. Jacobs, G. Lohoefer, and I. Seyhan

Institut für Raumsimulation

Deutsche Forchungsanstalt für Luft- und Raumfahrt

D-51140 Köln, Germany

The surface of a liquid drop can be excited to perform oscillations due to capillary forces. Consequently their frequencies depend on the surface tension and this relation can be used for the measurement of this important quantity. For spherical drops the fundamental frequency is given by Rayleigh's formula, $\omega^2 = (32\pi\gamma)/(3M)$ where γ is the surface tension and M the mass of the drop. In the case of liquid metals, electromagnetic levitation is an elegant way to position and melt a drop of a few grams. Under terrestrial conditions, both the gravitational field and the electromagnetic levitation field deform the droplet considerably, and Rayleigh's formula no longer holds. Instead, the broken symmetry leads to a splitting of the fundamental frequency, and the magnetic pressure exerted on the drop's surface lead to a shift of the frequency to higher values. Corrections to Rayleigh's formula have been proposed and verified experimentally. However, the ultimate proof for the validity of the corrections, and, eventually, for the values obtained for the surface tension, are experiments on spherical drops. The microgravity environment offers the possibility to perform such experiments. The residual gravitational accelerations are of the order $< 10^{-3}$ g_o, and the required electromagnetic positioning fields are reduced by the same amount. Therefore, these forces can be safely neglected, and Rayleigh's formula can be applied directly. Such experiments have been performed on board the Space Shuttle in the TEMPUS facility during Spacelab missions IML-2 (1994) and MSL-1 (1997) on a number of liquid metals and alloys. The frequency spectra clearly show a single peak which can be attributed to the fundamental frequency, and the derived surface tension values are in excellent agreement with data obtained on ground with electromagnetic levitation, but only if latter are corrected for the magnetic field effect.